A Report Overview

of the

Civil UAV Capability Assessment

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Introduction/Purpose

The National Aeronautics and Space Administration (NASA) is leading a significant effort to assess the capabilities of Uninhabited Aerial Vehicles (UAVs)[1] for civil use. A key part of this activity is to develop a report that will serve as a roadmap for the development of these applications. The intent of that report, which will complement the Office of the Secretary of Defense UAV Roadmap, is four-fold:

- To determine and document potential future civil missions for UAVs based on user-defined needs.
- To determine and document the technologies necessary to support those future missions.
- To discuss the present state of the platform capabilities and required technologies; identifying those in progress, those planned, and those for which no current plans exist.
- Provide the foundations for development of a comprehensive civil UAV roadmap.

The content of the assessment document will be updated periodically and used to evaluate the feasibility of future missions. In addition it will help influence funding decisions to develop technologies that are considered enabling or necessary but are not contained within approved funding plans and guidelines.

Note that while Department of Defense (DOD) missions are not considered as part of this assessment process, it is recognized that many of the enabling technologies developed for military UAVs will be similar or identical to those required for civil UAVs. As a result, this effort will require close and continuing coordination between NASA and DOD in order to utilize and include, where feasible, those military technologies that support civil missions. Likewise, it is expected that the efforts by NASA will lead to enhancements of some of the technologies needed for both military and civil applications and will be shared with DOD operators.

The purpose of this document is to give an abridged version of the UAV capability assessment report. In this way, the reader can gain enough knowledge of NASA's assessment to determine if UAVs have application within the reader's organization, and to determine if there is enough interest to examine the details contained within the full assessment.

[1] For purposes of discussion, this document will use the UAV definition described in the e AIAA Committee of Standards', "Lexicon of UAV/ROA Terminology". It defines a UAV to be: "An aircraft which is designed or modified, not to carry a human pilot and is operated through electronic input initiated by the flight controller or by an onboard autonomous flight management control system that does not require flight controller intervention."

History of UAVs

The notion of using UAVs, in one form or another, has been around since World War I. The US did not begin experimenting seriously with unmanned reconnaissance drones until the late 1950s. The idea of being able to carry out spy missions or deliver munitions on targets behind enemy lines without harm to a pilot has intrigued military planning strategists. Initial efforts to use the concept proved unsuccessful. However, the Vietnam War and the Cold War spurred a variety of development programs, which led to several reconnaissance drones, such as the Firebee and Lightning Bug.

The early UAVs were difficult to operate and maintain. The Air Force deployed them for a variety of missions, including gathering signals intelligence and collecting high- and low-altitude imagery both during the day and at night. The urgent need for unmanned aerial vehicles ended with the Vietnam War, but the services remained interested in exploring the capabilities that those aircraft had to offer. The military events in the Middle East since the 1990s have renewed the interest levels in UAVs. The performance by vehicles such as Predator and Global Hawk has stimulated interest in UAVs for civil usage.

For civil applications, NASA programs such as the PA-30 in 1969 looked at remotely controlling an aircraft from a ground station, but a pilot was in the cockpit to take over if the research didn't go as expected. NASA engaged in several other successful programs to help develop data bases for future UAV researchers such as the F-15 Spin Research Vehicle, a 3/8 scale aircraft; Drones for Aerodynamic and Structural Testing (DAST); and the Highly Maneuverable Aircraft Technology (HiMAT) program.

In the 1990s NASA-led a program, with industry partners, to develop technologies to assist a fledgling UAV market. This effort brought the potential of a commercial UAV market into focus. Continuing work developed from that effort seeks resolution of major technological and policy impediments that restrain the development of these aircraft to their full potential.. The nine-year long NASA program, called Environmental Research Aircraft and Sensor Technology (ERAST), helped to redefine UAV technology with research on engines, sensors and integrated vehicles that would conquer the barriers to high altitude, long-endurance (HALE) aircraft. Products resulting from the ERAST partnership include Pathfinder, Helios, Altus, and Perseus B, and potentially could result in vehicles with altitude ceilings above 100,000 feet and endurances up to 6 months.

Potential Civil Applications

The suitability of UAVs in "dull, dirty and dangerous" missions, the increasing success of UAVs in service and demonstration, the increases in payload capability of more recent Many technology forecasting publications have cited a wide range of applications that include UAVs taking on new missions, replacing the methods for existing missions and adding a new dimension to existing missions. Examples of these missions include:

- Border & Costal Patrol and Monitoring
- Homeland Security
- Law Enforcement & Disaster Operations
- Digital Mapping & Planning/Land Management
- Search & Rescue
- Fire Detection and Firefighting Management

- Communications and Broadcast Services
- Precision Agriculture and Fisheries
- Ground Transportation Monitoring and Control
- Satellite Augmentation Systems
- Air Traffic Control Support
- Power Transmission line Monitoring
- Environmental Research & Air Quality Management/Control

UAVs currently represent a relatively small segment of the aerospace market (about $1.25B in research and production funding in 2003). However, they constitute the one of the more dynamic portions of the industry. What attracts so much attention to them is the potential for a major expansion and new roles in both the defense and civil applications. Although UAV development for civil use is in the early stages, it appears that there are many uses being proposed for them. However, several pre-requisites must be satisfied to render the UAV a viable, cost effective and regulated alternative to existing resources. Major civil and commercial market barriers include:

- Lack of airspace regulation that covers all types of UAV systems (encompassing ‘sense and avoid’, airspace integration and airworthiness issues)
- Affordability - price and customization issues (e.g. commercial off-the-shelf, open modular architecture)
- Efforts to establish joint customer requirements
- Liability for civil operation
- Capacity for payload flexibility
- Sensor technology and miniaturization
- Lack of secure non-military frequency for civil operation
- Perceived reliability (e.g. vehicle attrition rate vs. manned aircraft)
- Operator training issues
- Recognition/customer perception
- Technology developments for multi-mission capability
- International barriers for use

For a civil market to develop, cost benefit analyses must support the use of these vehicles in lieu of current methods and for new missions not being done. In those cases where operator safety is the issue, the need to accomplish the mission becomes the focal point rather than the cost elements.

Market Forecast

Market forecasts for the UAV industry are tempered by the fact that they do not include the projections for payload costs or operational costs. The lack of inclusion of these cost elements makes it difficult to develop a very accurate forecast of the market in terms of dollar value. Table 1 lists various market forecasts based on the number of units of demand (basic systems) rather than total market value including operations and sensor suites. Some estimates place operating and sensor costs as being higher than the acquisition costs of the airframe and avionics. Of interest to this forecast is the fact that all indicate a high rate of growth in the number of units over the next ten years. By extension, the growth in the support market could be considered as explosive as well. For UAVs to play a future role in missions identified previously, price structure will play a major influence in the civil sector growth rate.

Of interest to this effort is the fact that the market forecasts for explosive growth in civil UAVs occurs in the same time frame that the technology forecasts indicate that the enabling UAV technologies will mature. With the insertion of new technologies and refinements of existing ones developed over this period, these market forecasts are on a path to become reality.

Source	Date	Forecast	Uses	Comments
Department of Defense	FY 2001 budget	Strike force to be 1/3 UAVs by 2010	Military	Airframe and avionics
Teal Group	Dec 2002	Market to double by 2014	Military, science, homeland security	Airframe and avionics
Frost and Sullivan	Oct 2003	5.5B EUR by 2012	Military, science, homeland security	Airframe and avionics
Forecast Int'l	Oct 2003	$10.6B by 2013 Massive growth 2010	Military, science, homeland security	Airframe and avionics
Teal Group	Aug 2004	$4.5B/yr by 2014	Military, science, homeland security	Airframe and avionics

Table 1. UAV Market Forecasts

Capability Assessment Structure

The organizational structure depicted in Figure 1 illustrates the hierarchy of potential users in the assessment document.

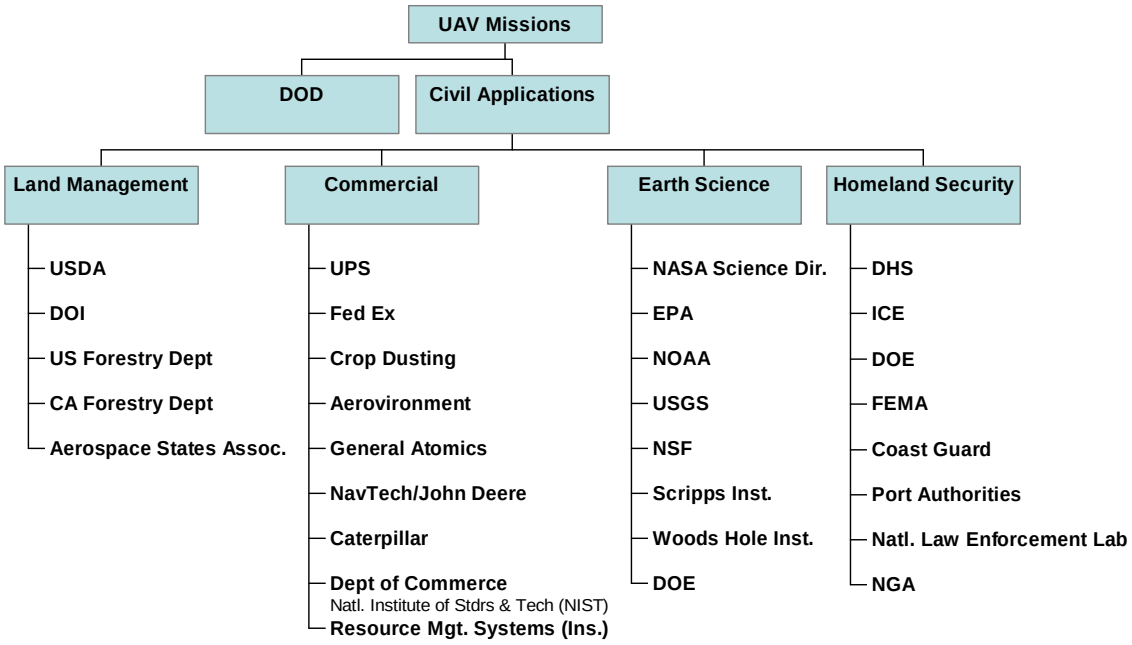
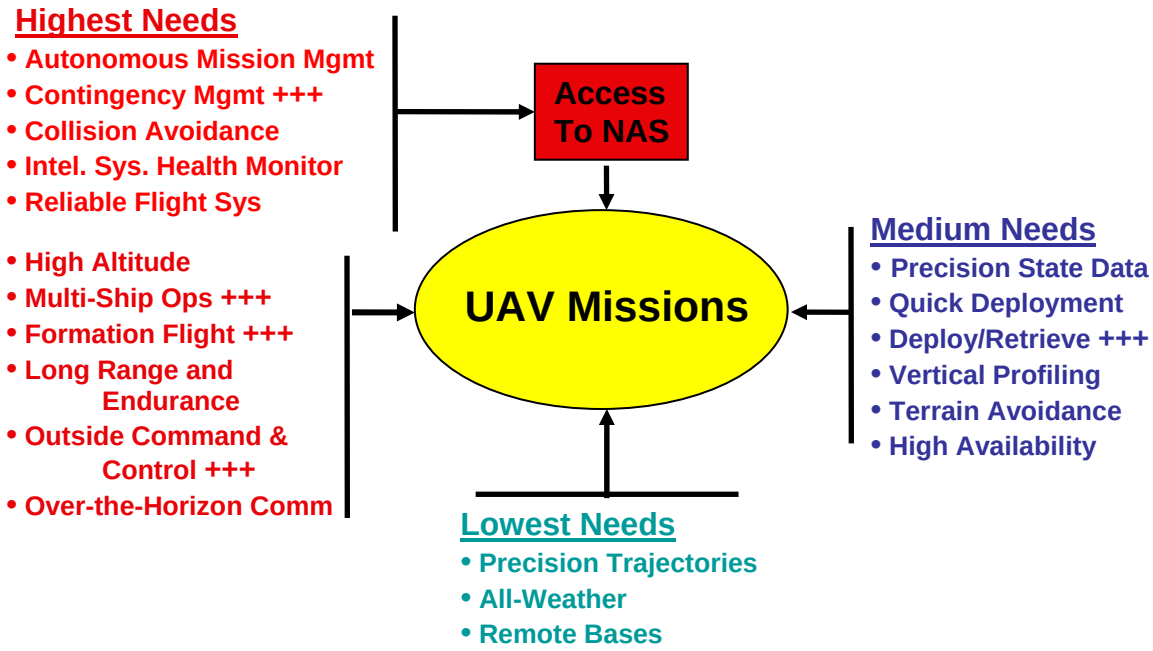


Figure 1. Classification of UAV Users

These categories indicate the current private and public sector organizations that have shown interest as potential users of UAVs. While DOD missions will not be considered as part of this report, it is recognized that many of the enabling technologies developed for military UAVs will be similar or identical to those required for civil UAVs. As a result, coordination between NASA and DOD will help to utilize and include, where possible, military technologies that support civil missions

For the civil UAV market to mature, there are various needs that must be met. Figure 2 depicts these needs in a schema based on analyses of inputs from workshops held with potential mission users and the expertise of the UAV Team. Some are being addressed currently through existing programs (e.g., Access to NAS) and others as indicated appear to have possible gaps in their development.



+++ = Possible Development Gap

Figure 2. UAV Mission Support Needs

The categorizations, from lowest to highest, are suggested based on the frequency they occur in the potential missions proposed at the workshops.

This report is the initial version of the Civil UAV Capabilities Assessment and, because of time constraints, is heavily weighted toward the Earth Science missions. Additional workshops and interviews are being conducted to fuel a major update and scope expansion to this document scheduled for completion in March 2006. Over the next year, the scope will be expanded, additional technologies may be identified, and the status of those technologies (and their developmental projects) will be improved and updated. Feedback will be sought from the UAV users regarding the accurate capture of missions and technologies. The March 2006 release will contain suggested paths to a greater UAV capability. Thereafter, minor updates will be made annually with a major update made in 2009. The schedule for these updates is shown in Figure 3.

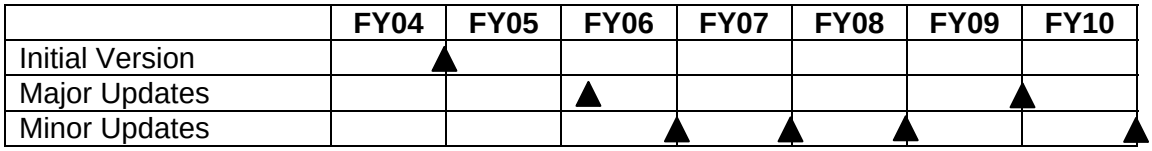


Figure 3. Civil UAV Capability Assessment Schedule

Final Thoughts

Two aspects of the President's Management Agenda are supported by this undertaking. First, it is one that will engage multiple Agencies in the effort as stakeholders and benefactors of the systems. In that sense, the market will be driven by the user requirements and applications. The second aspect is one of supporting economic development in the commercial sector. Market forecasts for the civil use of UAVs have indicated an infant market stage at present with a sustained forecasted growth. There is some difficulty in establishing the value of the market since the typical estimate excludes system components other than the aerial platforms. However, one fact that can be drawn from these forecasts is that all show a sustained growth rate for the long-term. A second point is that the market forecast for growth and the expected enabling technology maturation curves are congruent. Thus, the market demand should be there when the systems' capabilities are proven.

The goal of fostering the capabilities of UAVs can most easily be accomplished by removing many of the technical and regulatory barriers to civil UAV flight. This means that NASA must endeavor to develop technologies from the low technology readiness levels to ones that can be readily developed in the commercial sense. In addition, policies must be fostered to facilitate UAV flight in the National Air Space. As a result of these efforts, cost will become a lesser impact to market development. When these become reality, innovation and entrepreneurship will drive down the cost of UAV flights and enhance the safety, reliability, and operability of UAVs. As the costs go down and access to the airspace becomes routine, the market for UAV is expected to expand rapidly based on various market forecasts. This cost shift will drive the explosive market growth in the civil sector that is forecasted in several studies. This assessment will facilitate the market growth by identifying critical user-defined technology and capability requirements that currently do not have funding plans in place.